TOPIC G: Integration Testing

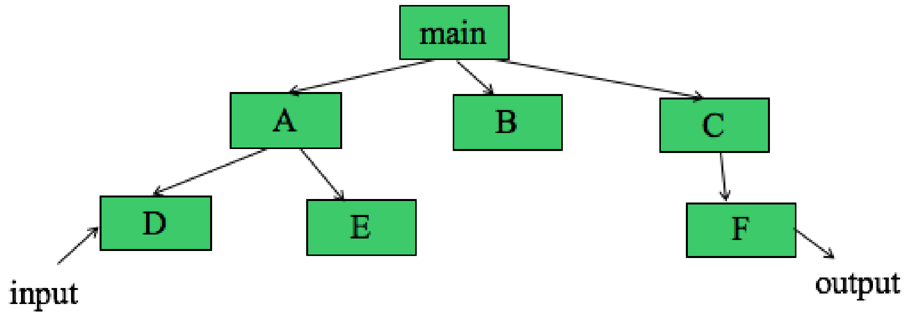
Ch. 6.1 and 6.2

Outline

- Big bang
- Top-down
- Bottom-up
- Sandwich
- Regression
- Two-tier and multi-tier integration testing
- Other types of integration testing

Integration Testing

- Assumes the units have been tested individually
- Tests units working together
- Identifies errors in the interfaces between units
- The goal is to ensure that components work fine when assembled
- Approaches
  - Big bang
  - Top-down
  - Bottom-up
  - Sandwich



Integration Testing – Possible Issues

- Assuming that units/components are tested, integration issues may arise due to Interfacing
    - Procedure/Method calls
    - Shared Memory
    - Message passing
    - Wrong assumption about provided functionality
    - Wring assumptions about the interface (wrong parameters, precondition checks)
    - Wrong error processing
    - Wrong assumption about events timing

Integration testing Stubs

- Stubs replace modules
  - Stub for input: the Stub produces test input data
  - Stub for output: returns test results
- Stubs can replace the whole component
  - For example, network, or a resource
- Stubs must be declared and invoked as the real module
  - Same name
  - Same parameter list
  - Same return type

Example Testing Stub

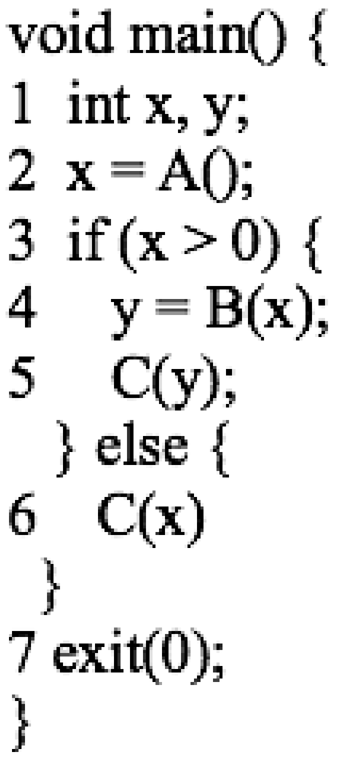
public static int someFunc(float fThat)

```
public static int someFunc(float fThat) {
  int iDummy = 42;
  System.out.println (“In method someFunc ” +
      “Input float =” + fThat);
  System.out.println (“Returning 42.”);
  return iDummy;
}
```

Integration testing Stubs

- Common functions of a stub
  - display/log trace message
  - display/log passed parameters
  - Return value according to test objective
    - from a table
    - from an external file
    - based on a search according to parameter value
    - ..

Example



```
void main() {
1  int x, y;
2  x = A();
3  if (x > 0) {
4      y = B(x);
5      C(y);
   } else {
6    C(x)
  }
7 exit(0);
}
```

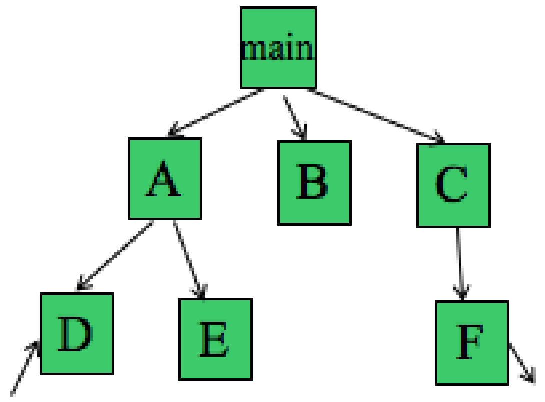
- If you want to test the Path 1-2-3-4-5-7
  - Use a stub for A() such that x>0 is returned
- If you want to test for Path 1-2-3-6-7
  - Use a stub for A() such that x<=0 is returned

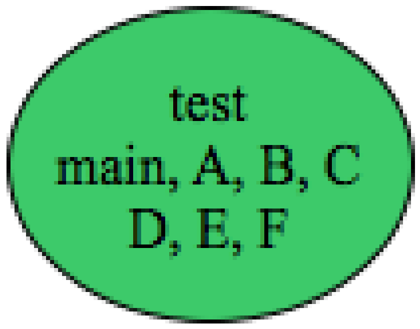
Drivers

- A Driver is a module that calls tested Module(s)
  - Drivers must provide required parameters.
  - Drivers must handle returned values

Big-bang Integration

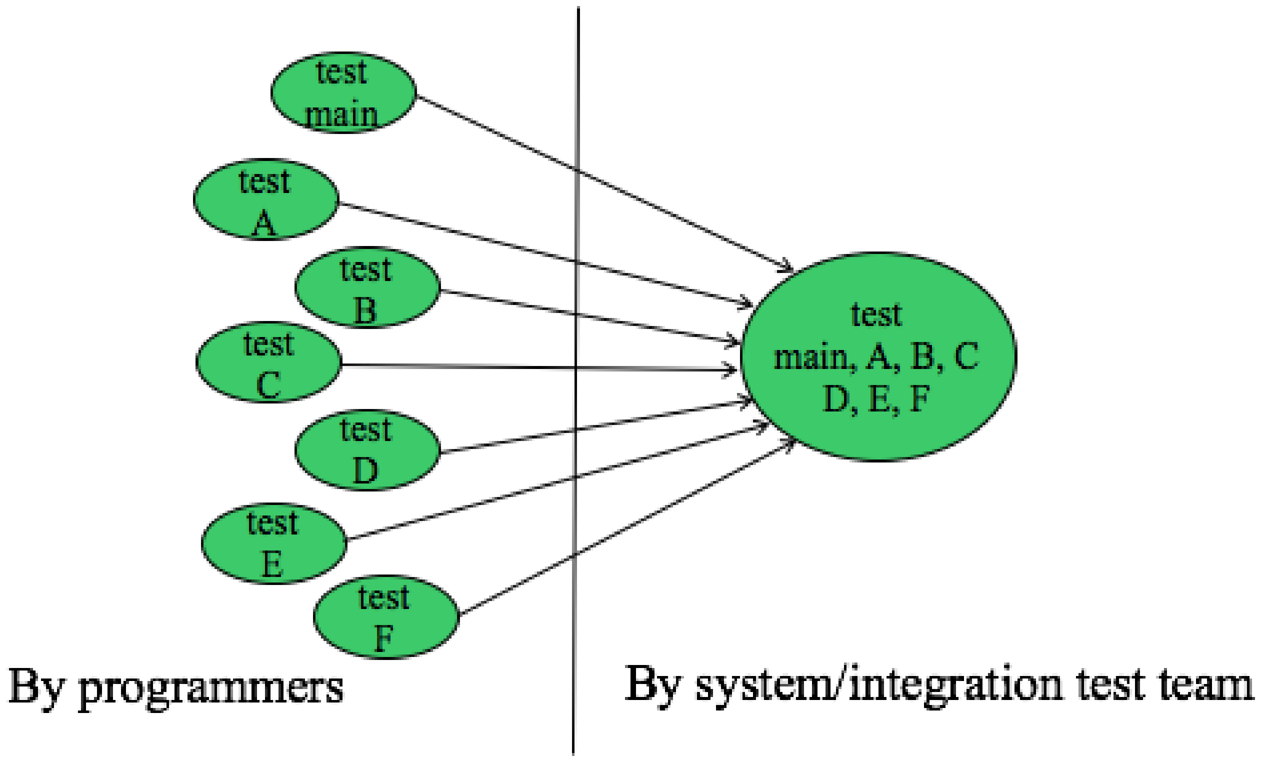
- Non-Incremental Strategy
- Test all components in isolation, then mix them all together and see how it works.
- As all components are merged at once, it is difficult to identify the cause of a failure.





Big Bang Integration

- Assumes all components are initially tested in isolation
- Clear division of responsibilities

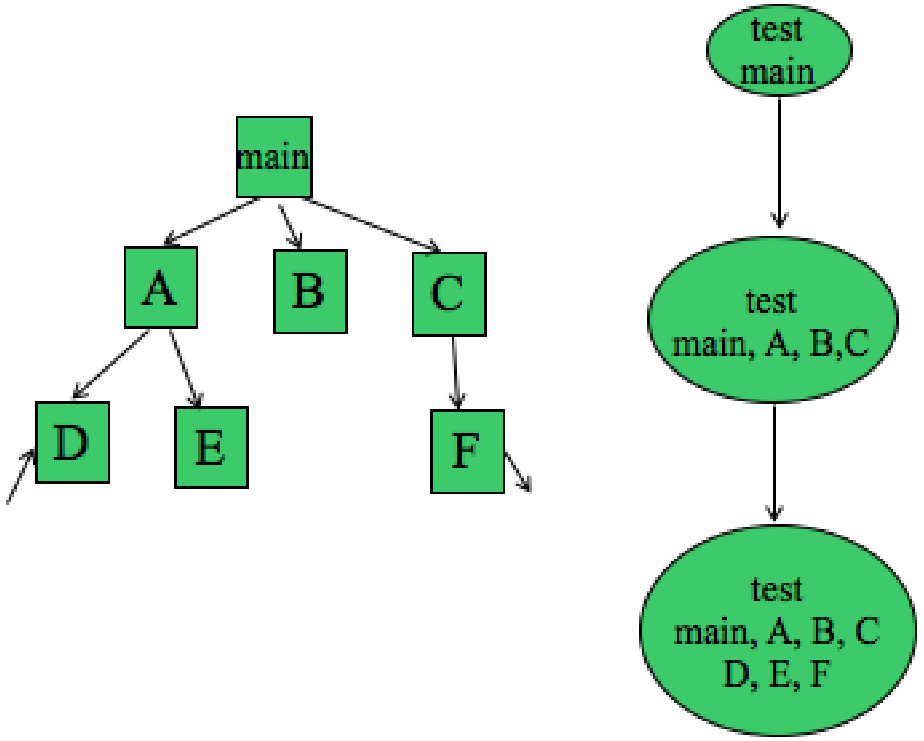


Advantages and Disadvantages

- Advantages
  - Convenient for small systems: Not too difficult to identify/localize errors
  - Can be performed frequently, or continuously: small systems' integration is not computationally expensive
- Disadvantages
  - Fall localization can be difficult for large systems
  - Not very suitable for parallel and incremental development

Top-Down Integration Testing

- Incremental Strategy
- Modules are integrated by moving downward through control hierarchy.
- Modules subordinate to main control module are incorporated
  - Depth-first
  - Breadth-first

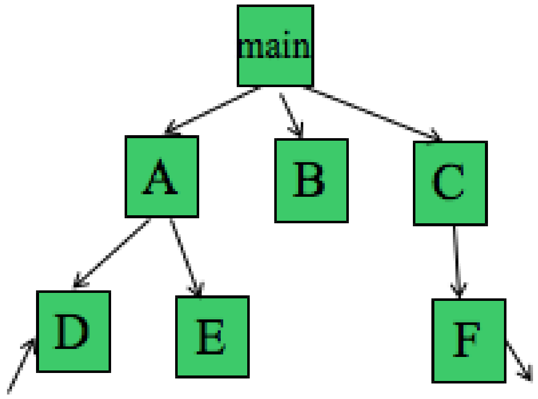


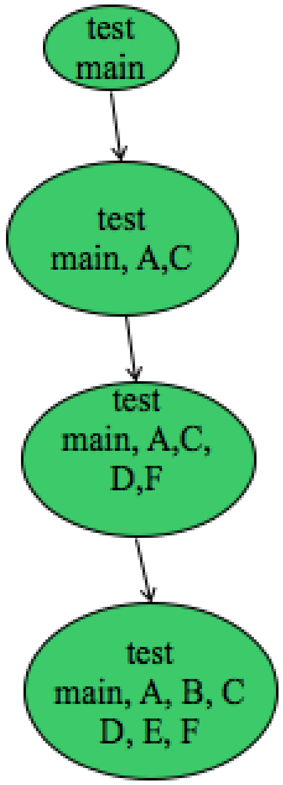
Steps in Top-Down Integration Testing

- The main module is used as a test driver
- Stubs are substituted for all components directly subordinate to the main control module
- Stubs are replaced one at a time with actual components
- Tests are conducted as each component is integrated.

Top-down Integration

- It is possible to alter the order to test as early as possible, for example:
  - To test critical components first
  - To test input/out components first





Evaluation of Top-Down Strategy

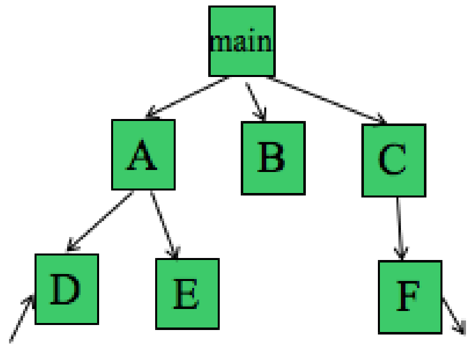
- Verifies major control or decision early in the test process
- Allows early recognition of major problems
- Depth first strategy allows a complete function of the software to be implemented
- Stubs replace lower-level modules so no significant data can flow upward
  - Delay some tests until have actual modules
  - Add code to simulate module

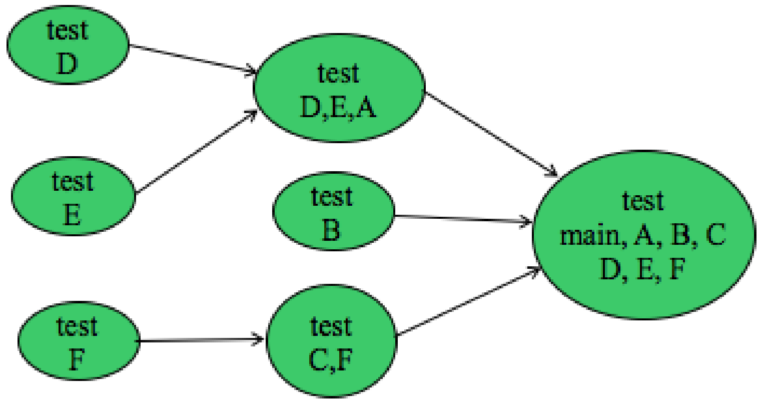
Advantages and Disadvantages

- Advantages:
  - Fault localization is easier
  - Fewer drivers are needed
  - Facilitates testing early prototypes
  - Can accommodate different order of testing and implementation
  - Major design flaws can be identified early because logic/high level design components are usually located at the top of the hierarchy.
- Disadvantages
  - Could require large number of stubs
  - Since reusable components tend to be at the bottom of the hierarchy, they may be inadequately tested.

Bottom-Up Integration

- Low-level components are combined into clusters
- A driver is written to coordinate test case input and output
- Cluster is tested
- Drivers are removed and clusters are combined moving upward in program structure.





Evaluation of Bottom-Up Strategy

- Need for stubs is eliminated (or significantly reduced)
- Operational modules tested thoroughly
- Begins construction and testing with atomic modules

Advantages and Disadvantages

- Advantages
  - Fault localization is simpler than big bang approach
  - No need for stubs
  - Reusable components are tested thoroughly
  - Testing can progress in parallel with implementation
- Disadvantages
  - Need test drivers
  - High level components are tested at the end of the test process (at last and least)
  - Not suitable to build high level skeletal system or prototype for testing

Sandwich Integration

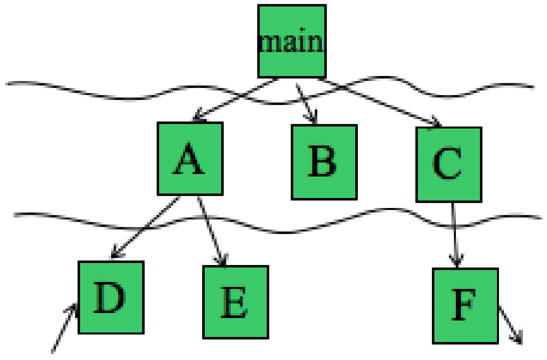
- Combination of bottom-up and top-down integrations
- System is viewed as layers
- Approach 1:
  - Top-down approach is used for the top layer
  - A bottom-up approach is used for the bottom layer
  - Allows integration to begin early in the testing phase
  - Does not test individual components thoroughly before integration

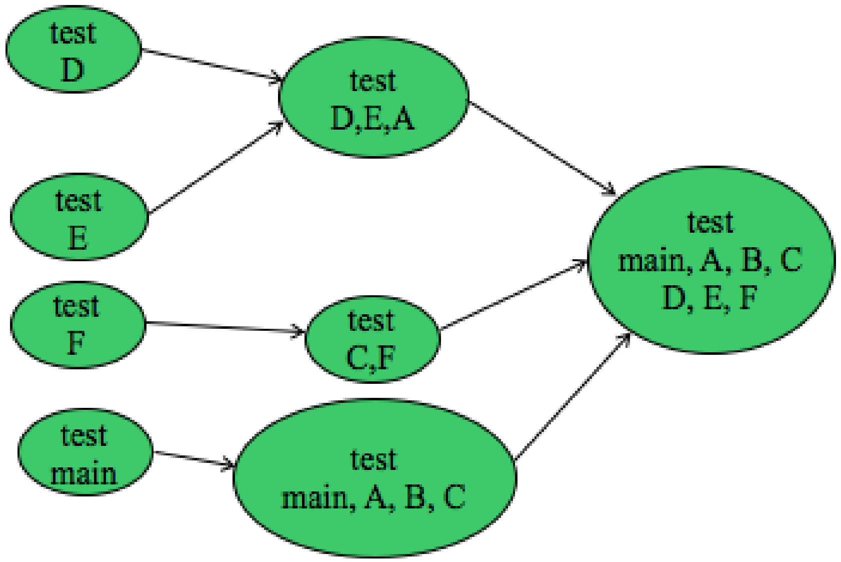
Sandwich integration (Cont.)

- Approach 2:
  - Start with a layer in the middle
  - Use drivers to and stubs to check
  - Work out from middle
  - Allows integration to begin early in the testing phase
  - Does not test individual components thoroughly before integration

Sandwich testing

- Combines top-down and bottom-up
- Three layers
  - Logic (top layer) tested top-down
  - Middle layer
  - Operational (bottom) tested bottom-up





Regression Testing

- Adding new or changing module impacts the system
  - New data flow paths established
  - New I/O may occur
  - New control logic invoked
- Regression testing is re-execution of subset of tests that have already been conducted
  - Ensures changes have not propagated unintended side effects

Regression Test (Cont.)

- Approaches
  - Manual testing
  - Capture/Playback tools: capture test cases and results for subsequent playback and comparison
- Test suite contains following classes of test cases:
  - Representative sample of tests that exercises all software functions
  - Focus on functions likely affected by change
  - Focus on components that have been changed

Risk-Driven Integration Testing

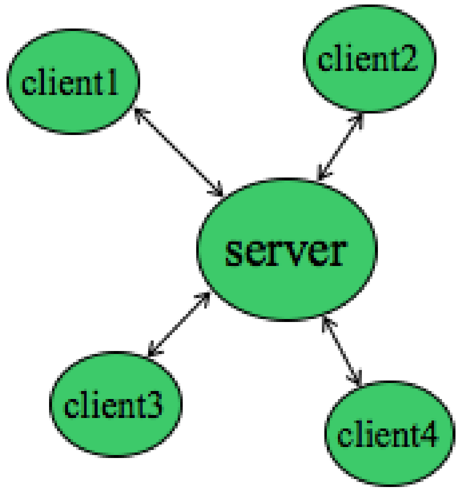
- Integration is based on criticality
- Most critical or complex components are integrated first.
- Facilitates early testing of high-risk components

Object-Oriented Integration using Mock Objects

- Mock Object
  - Designed based on Interfaces
  - Easier to set up and control
  - Isolates code from details that can be filled in later
  - Can be refined incrementally by replacing with actual code
- A **test double** is an object that can stand in for a real object in a test, similar to how a stunt double stands in for an actor in a movie. These are sometimes all commonly referred to as "mocks"

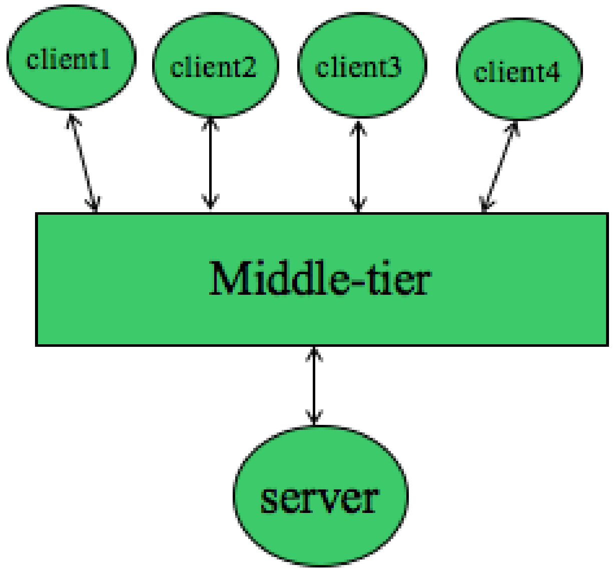
Client Server Integration

- Client-Server systems are two-tier systems
- Test Server with stubs for client types
- Remove all stubs and test server with actual clients
- Same approach work for multi-tier systems



Three-Tier Systems

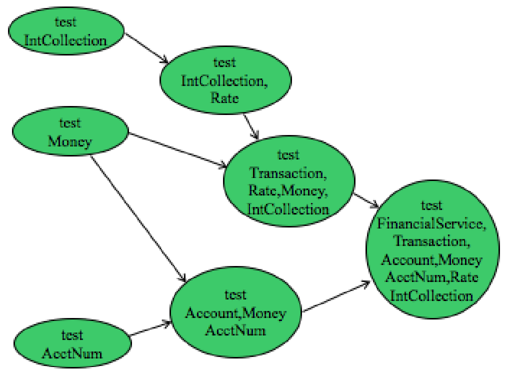
- Test each client with stubs for servers, and the middle-tier.
- Test server with stubs for each client types, and the middle-tier.
- Test each client with middle-tier and server proxy.
- Test server with middle-tier and client proxy.
- Test clients with middle-tier and the actual server.



Other types of integration testing

- Function/Thread Integration
  - Integrate components according to threads/functions they belong to.
- Use case based Integration
  - Integrate based on external use cases
- System/Sub-system Integration
  - Integrate sub-systems first
- Cluster Integration
  - Integrate start from leaves units

    and move up in dependency tree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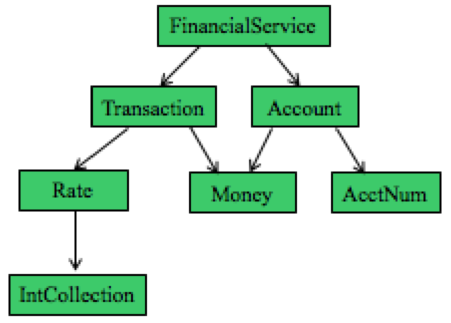
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